(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 038 553 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.09.2000 Bulletin 2000/39

(51) Int. Cl.[7]: **A62B 9/00**

(21) Application number: **00200959.5**

(22) Date of filing: **16.03.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **19.03.1999 GB 9906322**

(71) Applicant:
3M Innovative Properties Company
St. Paul, Minnesota 55133-3427 (US)

(72) Inventor: **Petherbridge, Ian T.**
Bognor Regis, West Sussex PO22 8NT (GB)

(74) Representative:
Hill, Cecilia Ann et al
Office of Intellectual Property Counsel,
3M Europe S.A./N.V.,
Hermeslaan 7
1831 Diegem (BE)

(54) Flow indicator device for respirators

(57) A respirator comprises a head piece (1) that is shaped to form a breathing zone (13, Fig. 2) around at least the nose and mouth of the wearer, and an air flow passage (15, Fig. 2; 34) for supplying a forced flow of air to the breathing zone. With a view to warning the wearer if the air flow to the breathing zone falls below a safe level, the air flow passage has a constricted portion (46) containing a flow detecting orifice (52) such that the forced flow of air generates suction at the flow-detecting orifice; and the respirator is provided with a pressure-responsive indicator device (30) that is in fluid communication through a tube (54) with the flow-detecting orifice and is operable to alert the wearer if the suction generated by the air flow through the passage falls below a predetermined value.

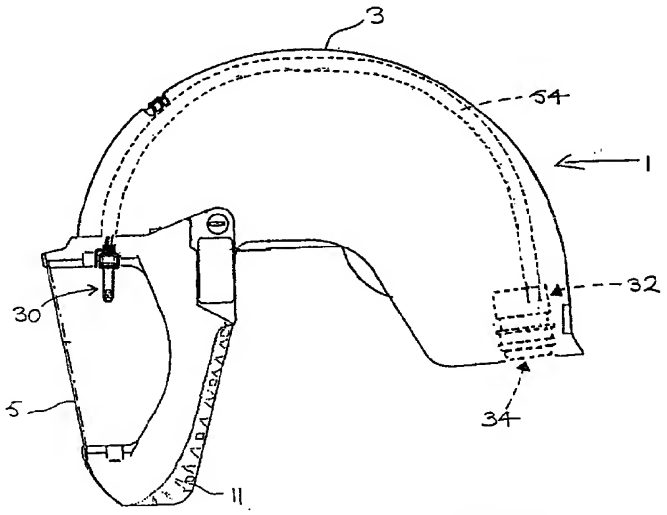

Fig. 3

EP 1 038 553 A2

Description

[0001] The present invention relates to respirators of the type that provides a forced flow of filtered air to the wearer.

[0002] One of the common purposes of a respirator is to prevent contaminants from entering the respiratory system of the wearer. A respirator typically comprises a head piece in some form, shaped to form a breathing zone around at least the nose and mouth of the wearer. In some respirators, the breathing action of the wearer alone causes air to be drawn into the breathing zone through some form of filter. Other respirators, however, provide a forced flow of filtered air to the breathing zone, thereby relieving the wearer of the need to inhale against the resistance of a filter and, at the same time, ensuring that any leakage in the respirator is outwards (i.e. from the breathing zone rather than into it). Respirators that use a forced flow are preferred in certain working environments, particularly those that are physically demanding on the wearer and those where the wearer is likely to benefit from the cooling effect of air flowing through the breathing zone.

[0003] A forced flow of air into the breathing zone of a respirator may be generated by a fan or by a blower which, together with its power source, may be carried by the respirator wearer (known as a powered system). Alternatively, the forced flow of air may be obtained from a source of compressed air, which may be either fixed or portable (known as a supplied air system).

[0004] Examples of respirators that provide a forced flow of filtered air to the wearer are described in US-A-4 133 308, 4 136 688, 4 280 491 and 4 462 399, and in GB-A-2 032 284. It is advantageous to provide a forced flow respirator with some form of indicator device that is capable of warning the wearer in the event that the air flow into the breathing zone falls below a safe level. Regulations are increasingly being introduced to make these indicator devices compulsory, for example the new European standard EN 12941. Examples of indicator devices that have previously been proposed are described in DE-A-30 32 371, GB-A-2 130 893, US-A-4 765 326, and in EP-A-0 349 191 and 0 602 847. It remains, nevertheless, desirable to provide an indicator device that will not add substantially to the cost of a respirator and will function reliably without substantially affecting the forced air flow into the respirator breathing zone.

[0005] The present invention provides a respirator for providing a forced flow of filtered air to a wearer, the respirator comprising:

a head piece that is shaped to form a breathing zone around at least the nose and mouth of the wearer;

an air flow passage for supplying a forced flow of air to the breathing zone, the passage having a constricted portion containing a flow detecting orifice such that the forced flow of air generates suction at the flow-detecting orifice, the degree of suction being related to the air flow rate in the passage; and

a pressure-responsive indicator device that is in fluid communication with the flow-detecting orifice and operable to alert the wearer if the suction generated by the air flow through the passage falls below a predetermined value.

[0006] As used herein, the term "air" includes breathable gases.

[0007] By way of example only, embodiments of the invention will be described with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a respirator in accordance with the invention;

Fig. 2 is a diagrammatic sectional view of the head piece of the respirator of Fig. 1 with certain components omitted, the head piece being shown positioned on the head of a wearer;

Fig. 3 is a side view of the head piece of the respirator of Fig. 1, with certain internal components being indicated by dotted lines;

Fig. 4 shows the components that are indicated by dotted lines in Fig. 3;

Fig. 5 is a cross-section taken on the line V-V in Fig. 4, shown enlarged;

Fig. 6 is a cross-section taken on the line VI-VI in Fig. 5;

Fig. 7 is an end view in the direction of the arrow VII in Fig. 6;

Fig. 8 is a cross-section taken on the line VIII - VIII in Fig. 6;

Fig. 9 is a cross-section taken on the line IX - IX in Fig. 4, shown enlarged, shown in Fig. 10 as VIII-VIII;

Fig. 10 is a perspective view of another respirator in accordance with the invention;

Fig. 11 is similar to Fig. 3 but shows the respirator of Fig. 10; and

Figs. 12 to 14 are perspective views of other forms of respirator in accordance with the invention.

[0008] The respirator shown in Fig. 1 includes a head piece in the form of a helmet 1. The helmet 1 comprises (i) a shell 3 that is intended to extend over the top, back and sides of the head of the respirator wearer, and (ii) a visor 5 that extends downwards from the front of the shell to cover the face of the wearer (see Fig. 2). In use, the shell 3 is supported on the wearer's head by a harness 7 (not visible in Fig. 1 but indicated diagrammatically in Fig. 2). A seal 9 (also not visible in Fig. 1 but shown diagrammatically in Fig. 2) is provided to seal the gap between the shell 3 and the wearer's head, and a flexible membrane 11 extends from the lower edge of the visor 5 to bear against the wearer's chin and close the bottom of the helmet. The helmet 1 thus defines a

substantially closed breathing zone 13 (Fig. 2) around part of the wearer's head including the wearer's nose and mouth.

[0009] A flexible hose 15 extends from the rear of the helmet 1 to connect the interior of the helmet to a power pack 17 that is provided with a belt 19 so that it can be carried at the wearer's waist. The power pack 17 contains a fan (not visible), a battery-powered DC motor (not visible) for driving the fan, and filter cartridges 21 through which air is drawn by the fan for delivery into the hose 15 and then into the interior of the helmet 1. A control knob 23 for the DC motor is located on the outside of the power pack 17, where it is readily accessible by the respirator wearer. The filter cartridges 21 are replaceable and may be designed to remove dust and/or noxious gases from the air, depending on the environment in which the respirator is to be used.

[0010] When the respirator is in use, filtered air from the power pack 17 is delivered into the chamber 13 around the wearer's head and is inhaled by the wearer. Surplus filtered air and exhaled air leave the chamber 13 by natural leakage at the seals 9 (Fig. 2), 11 or through vents that are formed in the helmet 1 adjacent the wearer's mouth specifically for that purpose. In some cases, a one-way outlet valve is provided in the helmet adjacent the wearer's mouth to provide a route by which surplus filtered air and exhaled air can leave the chamber 13, but that is not essential. The rate at which surplus filtered air and exhaled air leave the helmet typically causes a slight positive pressure (of about 2 to 4 Pa) to build up within the chamber 13, but that is also not essential.

[0011] As shown in Fig. 3, an indicator device 30 is provided, within the helmet 1 adjacent the visor 5, to warn the wearer whenever the rate of flow of filtered air into the helmet falls below a predetermined level. To enable that flow rate to be detected, a venturi device 32 (described in greater detail below) is provided within the helmet 1 at the air inlet from the hose 15. The venturi device 32 is a generally cylindrical moulded component that is shaped externally at its inlet end 34 for attachment to the end of the hose 15, preferably by means of a quick-release connection that permits the hose to swivel relative to the helmet. Internally, as described below, the venturi device provides an air flow passage through which the filtered air supplied by the hose passes to the chamber 13 within the helmet, and also enables the air flow rate to be detected.

[0012] Figs. 5 to 8 show the internal construction of the venturi device 32. The external walls of the device define a main passage 36 of circular cross-section extending from the inlet end 34 of the device to the outlet end 38. Over the first part 40 of its length, the passage 36 is of substantially constant diameter but then widens out towards the outlet end 38. A smaller diameter tube 42 is supported by integral diametric ribs 44, within the part 40 of the main passage 36 and is preferably, but not essentially, coaxial with the latter. The tube 42 and ribs 44 extend for the length of the part 40 of the main passage 36 and effectively constrict the latter so that, when the device 32 is attached to the end of the hose 15, the main passageway 36 forms a venturi that has part 40 as its throat. The tube 42 is also formed internally with the customary venturi shape (see Fig. 5) comprising a throat 46 of narrower cross section than the tube inlet 48 and outlet 50. The tube 42 constitutes an auxiliary venturi positioned within the primary venturi formed by the main passage 36.

[0013] As shown in Fig. 6, a right-angle passage 51a, 51b extends from an orifice 52 on the longitudinal axis of the throat 46 of the auxiliary venturi 42 and into communication with a connector tube 54 that extends, inside the shell 3 of the helmet, to the indicator device 30. The tube 54 is curved to follow the shape of the top of the helmet so that, when the helmet is in use, it extends over the top of the wearer's head. When the hose 15 is connected to the helmet 1, filtered air that is supplied from the power pack 17 enters the breathing zone 13 via the venturi device 32. A portion of the air passes into the auxiliary venturi 42 and, in so doing, generates suction at the orifice 52. The degree of suction is dependent (as is well known) on the air flow rate through the auxiliary venturi 42. The suction is applied, through the connector tube 54, to the indicator device 30 and is used to operate the latter as described below.

[0014] As shown in Fig. 9, the indicator device 30 comprises an open-ended indicator tube 56 that is preferably formed from a transparent material and that contains a float in the form of an indicator ball 58 that is visible through the tube. The indicator tube 56 is widened out at one end 57 so that it can be located in a coupling member 60 by which it is attached to the end of the connector tube 54 from the venturi device 32. The coupling member 60 is opaque so that the indicator ball 58 can not be seen when is located within this widened end of the indicator tube 56. The other end of the indicator tube 56 has a reduced opening 59 to the interior of the helmet 1, and a small step 62 is formed in the bore of the tube adjacent this opening 59, whereby the bore has three distinct sections 56a 56b and 56c of successively increasing diameter in the direction away from the opening.

[0015] An adhesive-backed mounting flange 61 (Fig. 4) extends from the coupling member 60 and is used to attach the coupling member to a suitable location inside the helmet so that the indicator tube 56 is positioned vertically in the field of vision of the wearer, with the open end of the tube being lowermost. When the helmet 1 is not in use, the indicator ball 58 is located in the smaller-diameter section 56a of the bore of the tube 56 adjacent the opening 59, as shown in Fig. 9.

[0016] The indicator ball 58 is formed from a light material (for example, polystyrene) so that, when the helmet 1 is in use, suction applied through the coupling member 60 as a result of air flow through the venturi device 32 draws air in through the opening 59 and

causes the ball to rise up inside the tube 56. The effect of the step 62 in the bore is that the ball 58 will tend to hover at the level of this step when the air flow through the venturi device 32 is low and will rise up into the widened end portion 57 when the air flow is at a normal safe level. In the latter location, the ball 58 is obscured by the coupling member 60 and is not visible to the wearer of the helmet. If the air flow through the venturi device 32 drops while the respirator is in use (for example because the filters 21 become blocked or the batteries in the power pack fail) the suction applied through the coupling member 60 will also fall and, depending on the magnitude of the reduction, may cause the indicator ball 58 to fall and hover once again at the level of the step 62 where it will be clearly visible to the wearer. An adjustment screw 64 extends through the coupling member 60 into the bore of the indicator tube 56 to enable the effect of the suction on the indicator ball 58 to be adjusted so that the latter descends from the end portion 57, and is visible to the wearer, only when the air flow through the venturi device 32 drops to an unsafe level. The provision of the adjustment screw 64 removes the need for the indicator ball 58 to be made accurately to a particular size, and also enables the indicator device 30 to be adjusted for different air flows through the venturi device 32.

[0017] The construction of the venturi device 32 shown in Figs. 5 to 8 (in particular, the positioning of the auxiliary venturi 42 in the throat 40 of the primary venturi) has the effect of amplifying the suction effect generated at the orifice 52 by a particular air flow into the helmet 1 making it possible, if required, to use some other form of indicator device instead of the ball indicator 30. For example, the suction generated at the orifice 52 could be applied to a pressure responsive switch and use to actuate an electrically-operated warning device such as an LED. Alternatively, it could be used to generate a feedback signal for controlling operation of the motor that drives the fan in the power pack 17, whereby the speed of the motor is increased if the air flow into the helmet 1 falls. As a further alternative, a warning device that generates some other form of signal (for example an audible signal) instead of, or in addition to, a visual signal could be used. The particular form of the venturi device 32 described above is not essential, however, and it would be possible to use a simpler form comprising a single venturi only.

[0018] An exemplary venturi device 32 of the type shown in Figs 5 and 6 has the following dimensions:

diameter of passage 36 at the inlet 34: 26mm
diameter of tube 42 at the inlet 34: 10mm
length of passage 36: 40mm
length of tube 42: 20mm.

Using such a venturi device 32, it is possible to produce a pressure reduction, at the orifice 52, of the order of 13 -14Pa when the air flow rate through the device is 160 1/min, which is typical for a system of the type shown in Fig. 1. The total air flow generated by the power pack 17 is delivered to the breathing zone 13 of the respirator helmet 1, and the additional restriction created in the air flow path by the venturi device 32 is found not have a significant impact on the operation of the system.

[0019] Indicator devices of the general type shown in Fig. 9 are known, and any suitable known (or later developed) form may be employed in combination with the venturi device 32. The form shown in Fig. 9 is advantageous, however, because the provision of the seat 62 at which the indicator ball 58 will hover even at very low air flows (of the order of 50 1/min) reduces the risk of the ball sticking in the lower end of the indicator tube 56.

[0020] The location of the indicator device 30 can be changed, depending on the form of the device and the form of the respirator in which it is used. It is not essential that the device be positioned directly in front of the wearer's eyes provided it is capable of attracting the wearer's attention when necessary. It is not even essential for the indicator device 30 to be positioned inside the helmet 1, although that location does offer the advantage that air drawn into the indicator tube 54 is clean. The indicator device could, in fact, be in any location in which it is capable of issuing a warning when the air flow into the helmet is low.

[0021] The venturi device 32 also does not have to be located on the helmet 1. It could be located anywhere in the path of the forced air flow into the helmet, for example at the outlet from the power pack 17.

[0022] The respirator shown in Fig. 1 is merely one example of a powered respirator in which the indicator 30 and flow-detecting venturi device 32 can be used. Many other forms of powered respirator are available. In some respirators, for example, the fan and air filter are located in the respirator helmet itself rather than at the wearer's waist in the separate power pack. The relative positions of the fan and filter are also interchangeable, regardless of where they are actually located (i.e. the fan may be upstream of the filter, rather than downstream as in the system of Fig. 1). It is also not essential that a fan be used to provide the forced flow of air for the respirator; in some cases, a centrifugal blower may be used instead.

[0023] The headpiece of the respirator may also take other forms. For example, it may retain the helmet form shown in Fig. 1 but be provided, additionally, with a hard hat inside the shell 3, which fits around and further protects the head of the wearer. In another case, the headpiece may be required to provide only respiratory protection for the wearer. In that case, it may comprise simply a face mask or visor (possibly with a hood to cover, but without providing protection for, the head of the wearer). Figs. 10 and 11, for example, show a head piece comprising a visor 70 with a loose fitting hood 72 at the rear of which is a venturi device 32 of the type shown in Figs. 5 to 8, providing a passage for a forced

air flow into the head piece and controlling operation of an indicator device 30. Fig. 12 shows a full face mask intended to cover the eyes as well as the nose and mouth of the wearer, with the air inlet 74 (and also an outlet valve 76) provided at the front of the mask. In this case, the flow-detecting venturi device 32 could be located in the air inlet 74 and connected to an indicator device positioned inside the mask in the field of view of the wearer. Fig. 13 shows a head piece comprising a visor 78 and a head harness 80, and an air duct 82 extending over the top of the wearer's head to carry a forced flow of air to the inside of the visor. In this case, the venturi device 32 is located in the inlet of the air duct 82 and is connected, through a tube located within the air duct, to an indicator device within the visor in the field of view of the wearer. Fig. 14 shows yet another head piece comprising a generally cylindrical head enclosure 84 formed from a transparent material and provided with a cape 86 for covering the upper part of the body of the wearer. The head piece has a supply pipe 88 for carrying a forced flow of air to the interior of the head enclosure 84, the inlet of which is provided with a venturi device 32 connected via a tube 54 to an indicator device 30.

[0024] In each of the respirators shown in Figs. 10 to 14, the external shape of the venturi device 32 (especially towards the outlet end 38, see Fig. 5) is adapted to suit the particular form of the head piece.

[0025] As a further alternative, the indicator device 30 and flow-detecting venturi device 32 may be used in a so-called supplied air respirator system in which the forced flow of air into the respirator headpiece is provided by a source of compressed air, which may be either fixed or portable.

Claims

1. A respirator for providing a forced flow of filtered air to a wearer, the respirator comprising:

   a head piece that is shaped to form a breathing zone around at least the nose and mouth of the wearer;
   an air flow passage for supplying a forced flow of air to the breathing zone, the passage having a constricted portion containing a flow detecting orifice such that the forced flow of air generates suction at the flow-detecting orifice, the degree of suction being related to the air flow rate in the passage; and
   a pressure-responsive indicator device that is in fluid communication with the flow-detecting orifice and operable to alert the wearer if the suction generated by the air flow through the passage falls below a predetermined value.

2. A respirator as claimed in claim 1, in which the indicator device is positioned within the breathing zone.

3. A respirator as claimed in claim 1 or claim 2, in which the indicator device is responsive to the pressure differential between the breathing zone and the flow-detecting orifice.

4. A respirator as claimed in any one of the preceding claims, in which the indicator device comprises a tube in which a float is located, the tube being connected at one end to the flow-detecting orifice and being open at the other end, such that the position of the float indicates the air flow rate in the air flow passage.

5. A respirator as claimed in any one of the preceding claims, in which the constricted portion of the air flow passage comprises a primary venturi; and an auxiliary venturi is positioned within the primary venturi to receive part of the air flowing therethrough; the flow-detecting orifice being located within the auxiliary venturi.

6. A respirator as claimed in claim 5, in which the auxiliary venturi is coaxial with the primary venturi.

7. A respirator as claimed in claim 5 or claim 6, in which the outlet of the auxiliary venturi is positioned in the throat of the primary venturi.

8. A respirator as claimed in any one of the preceding claims, in which the head piece provides a breathing zone which also covers the eyes and at least part of the top, back and sides of the wearer's head.

9. A respirator as claimed in any one of the preceding claims, in which the constricted portion of the air flow passage is located on the head piece.

10. A respirator as claimed in any one of the preceding claims, further comprising a source of pressurised filtered air connected to the air flow passage.

11. A respirator as claimed in claim 10, in which the source of pressurised filtered air comprises a fan and air filtering means; the fan being operable to direct ambient air through the filtering means and to direct filtered air to the breathing zone.

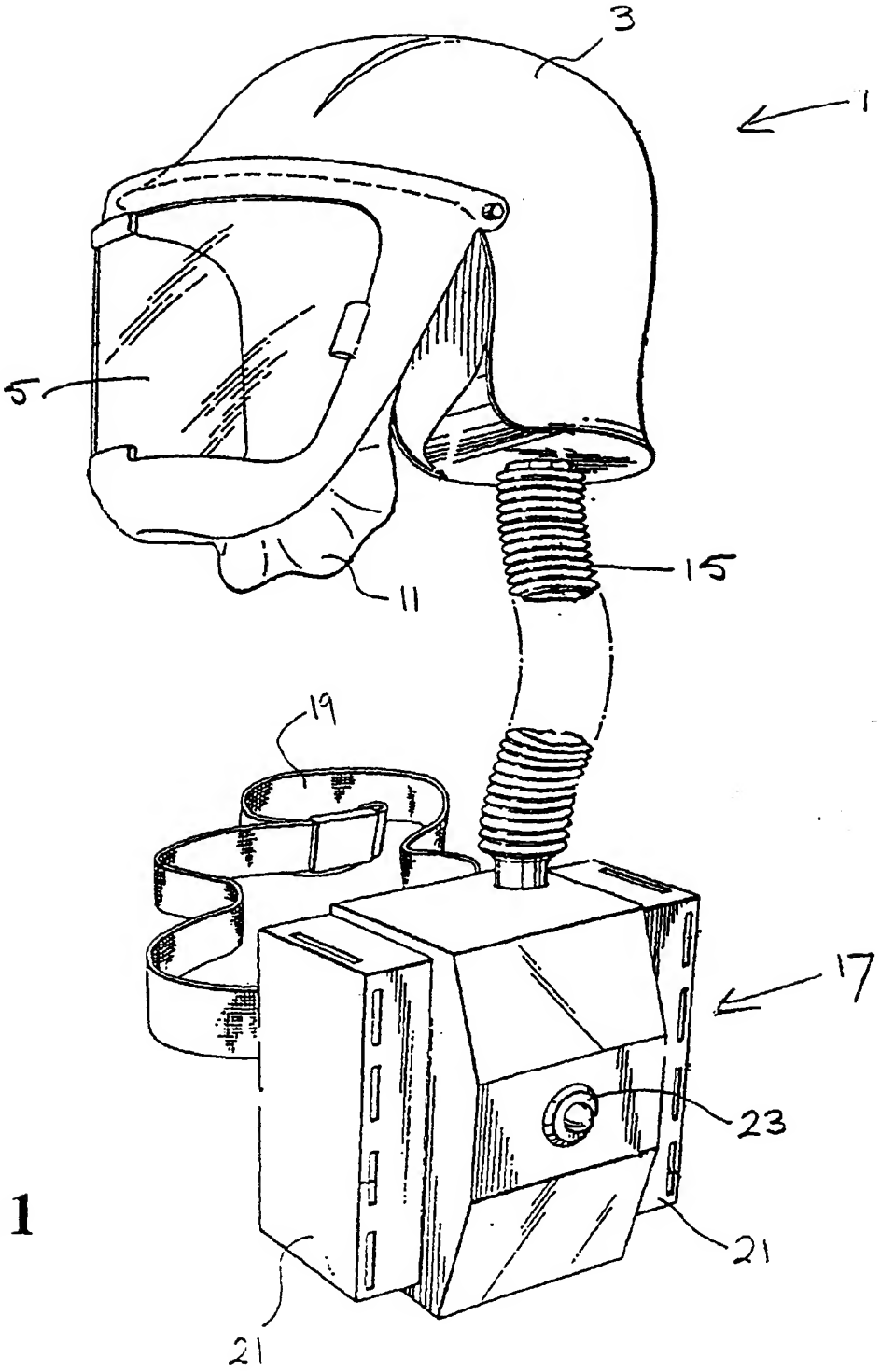

Fig. 1

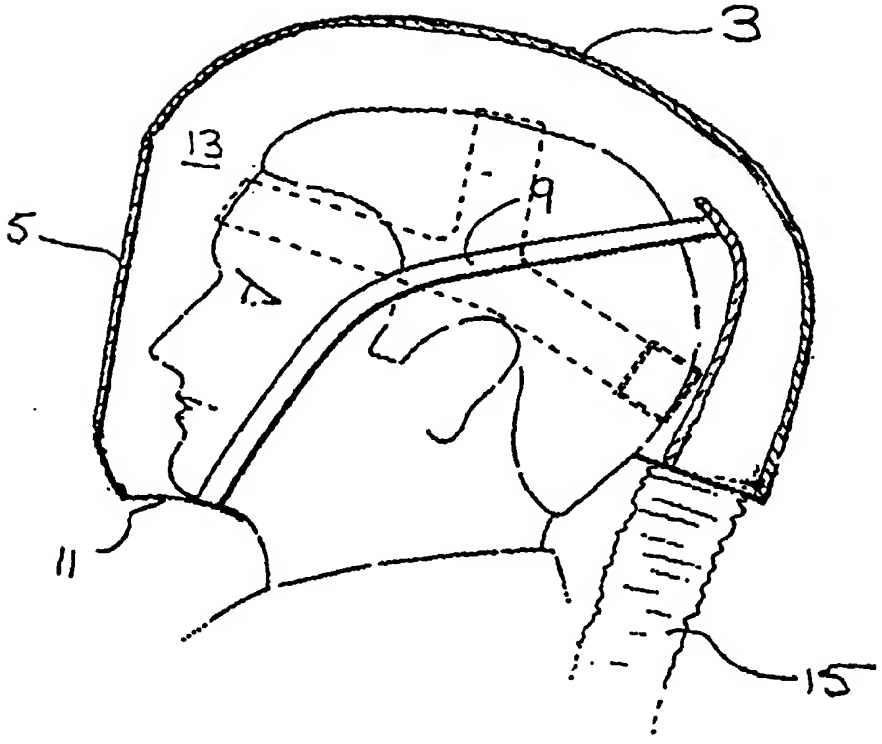

Fig. 2

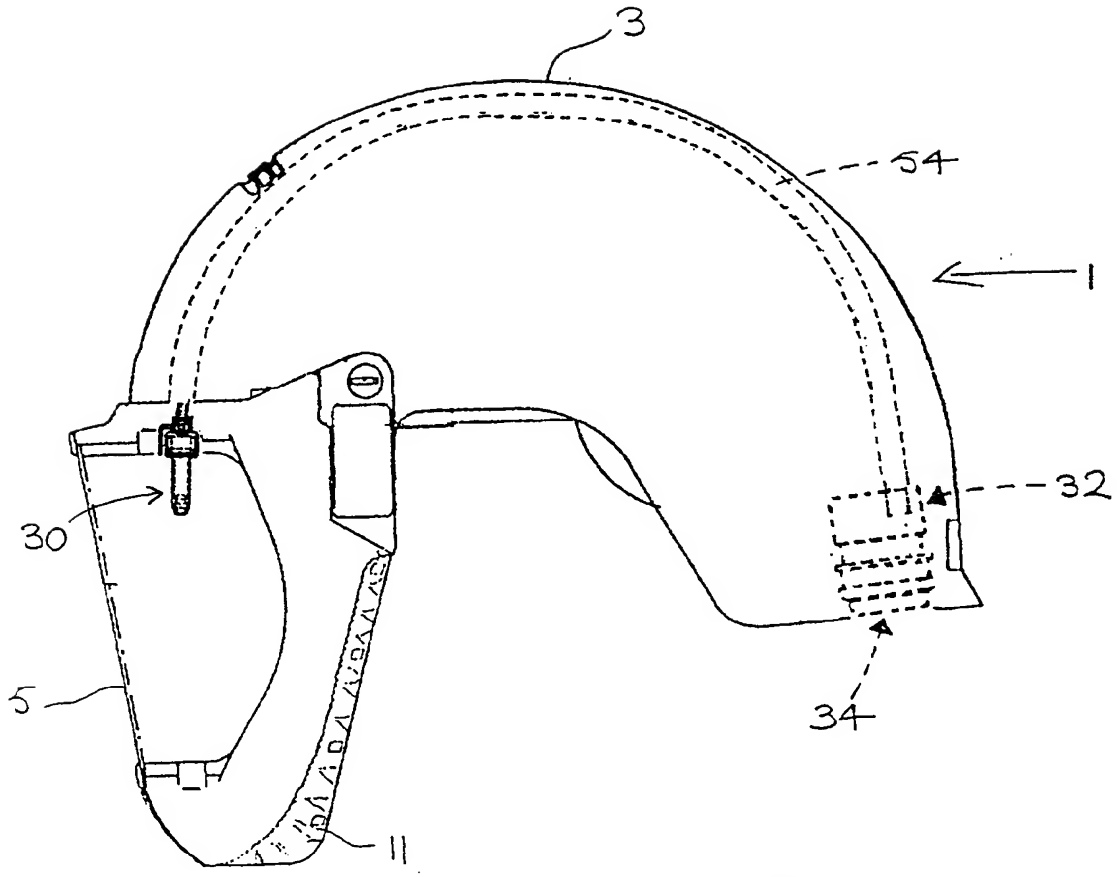

Fig. 3

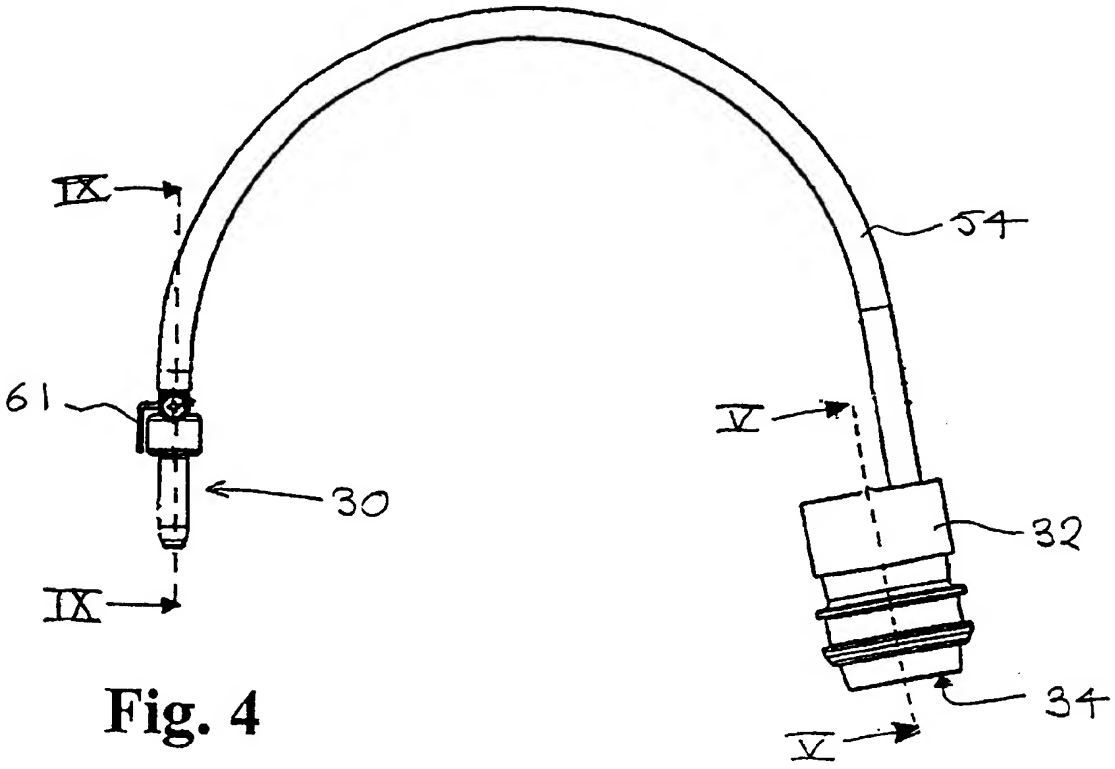

Fig. 4

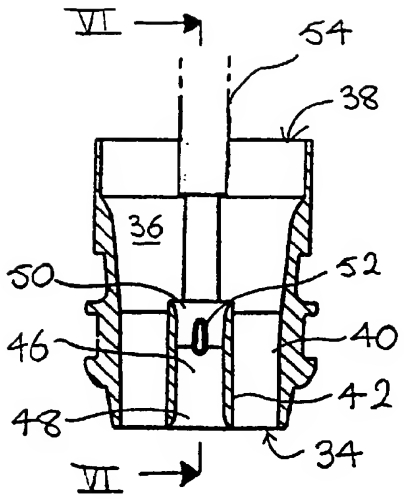

Fig. 5

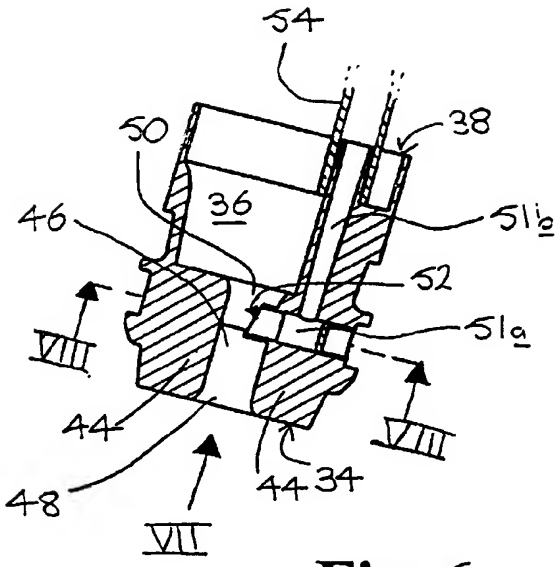

Fig. 6

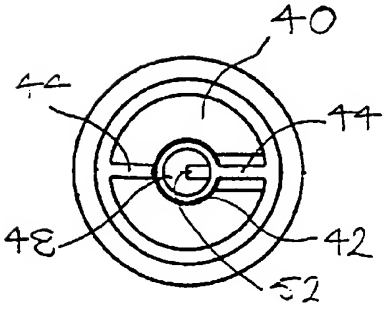

Fig. 7

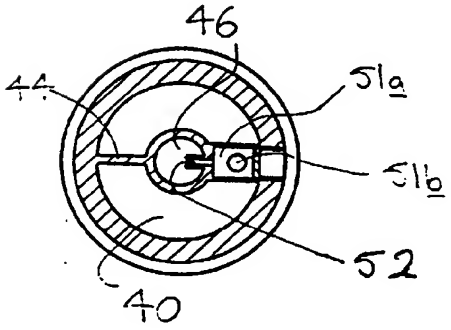

Fig. 8

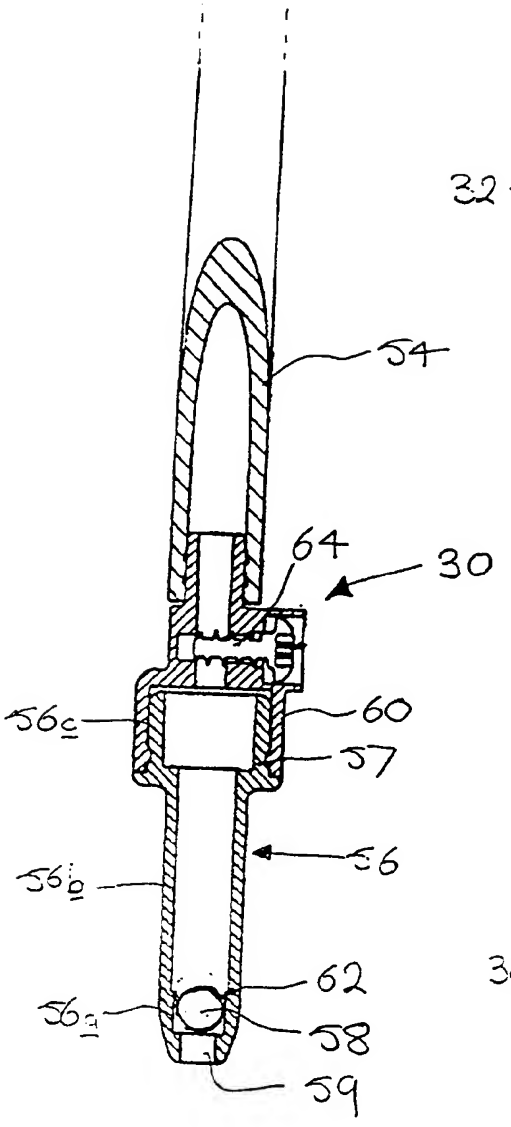

Fig. 9

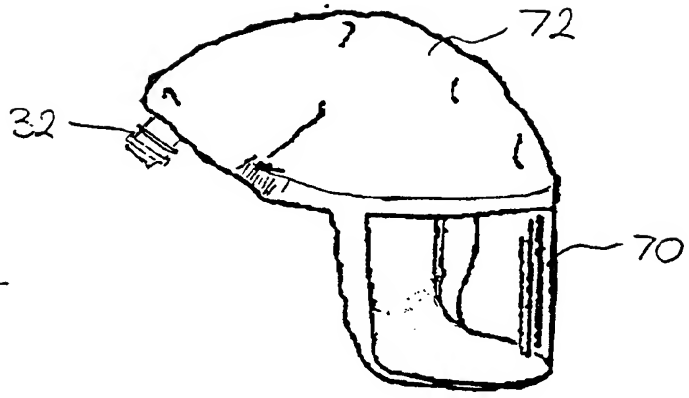

Fig. 10

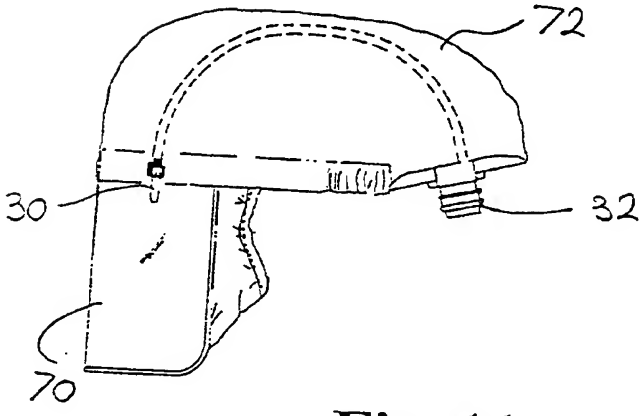

Fig. 11

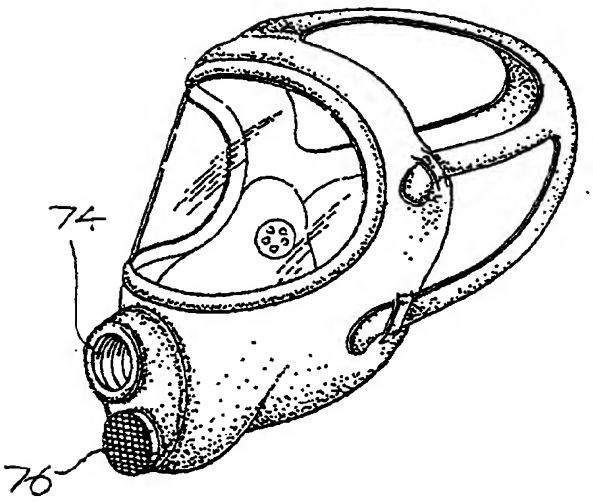

Fig. 12

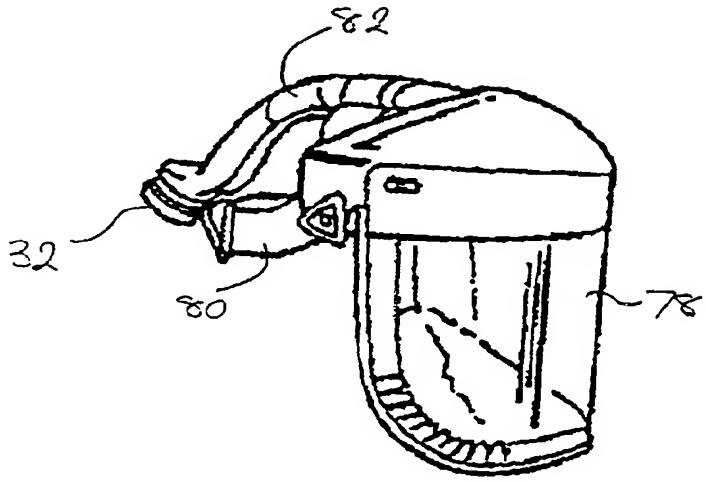

Fig. 13

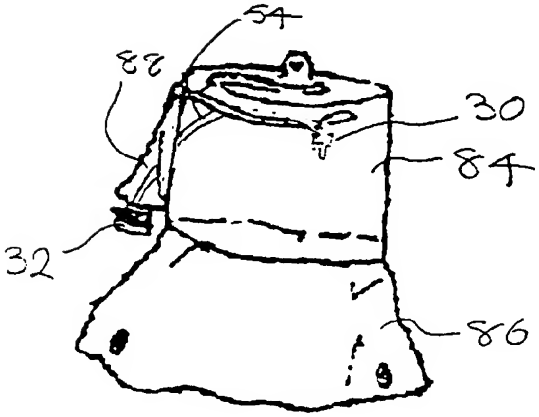

Fig. 14